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COLLEMBOLA AND PROTURA IN A MEADOW - FOREST ECOTONE

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1. Introduction

Great attention has been paid to ecological studies of ecotones in the last ten years, not only by scientific institutions but also by international scientific bodies, and some international programmes were started to understand better the structure and function of ecotones (SCOPE, MaB, IGBP). We studied some ecotones of different size scales in the Institute of Soil Biology through a team of soil zoologists, microbiologists and chemists (Rusek, in press). Some results of the distribution of Collembola and Protura in a mesoscale ecotone between a meadow and a spruce forest are presented here.

In a joint SCOPE - MaB meeting, Paris 1987, the definition of ecotones was fixed as follows: "Ecotone is a zone of transition between adjacent ecological systems, having a set of characteristics uniquely defined by space and time scales and by the strength of interactions between adjacent ecological systems" (di Castri et al, 1988). It is supposed that changes in ecotones precede changes in the bordering ecological systems. That is why such a great programme as the IGBP is also interested in ecotonal studies. In the present contribution I will demonstrate the ecotonal effect on the structure of Collembolan and Proturan communities and on the distribution of different species across a meadow - forest ecotone.

2. Site description

The ecotone was studied in Central Bohemia near Jevany, 200 m SE from the road Jevany - Černé Voděrady (350 m a. s. l.), ca 800 m before Č. Voděrady, on the edge of a meadow and Luzuleto pilosae - Abietum forest type; soil type: cambisiol on loess. The ecotone is situated on the SW forest edge. Six zones were determined across the ecotone:

Zone I (meadow) was on a mild, humid, recultivated meadow, sample sets 1-4. Humus form is mull. Dominant grasses are Dactylis glomerata L. and Deschampsia cespitosa P. - Beauv. accompanied by Holcus lanatus L., Poa cf. angustifolia (L.), Carex leporina L., Plantago major L., Chrysanthemus leucanthemum L., Alchemilla vulgaris L.s.l., Achillea millefolium L.

Zone II(meadow edge) was on the meadow edge, sample sets 5-8. Grasses dominante this zone but their density is lower than in the meadow and 20% of the soil surface is covered with mos-

Table 1: Abundance (ex.100 cm^{-2}) of the established Collembola and Protura in the I - VI ecotonal zones. H' - Shannon - Weaver index of diversity.

species: zone:	I	II	III	IV	V	VI
Collembola:						
Lepidocyrtus lignorum (Fabricius,1781)	22.5	2.5	-	-	2.5	-
Lepidocyrtus cyaneus Tullberg,1871	5	-	-	1.2	-	-
Lepidocyrtus lanuginosus (Gmel.,1788)	1.2	8.7	5	1.2	1.2	-
Pseudosinella hercynica Rusek,1979	1.2	15	17.5	7.5	6.2	6.2
Willowsia buski (Lubbock,1869)	1.2	-	-	-	-	-
Entomobrya nivalis (Linné,1758)	-	-	2.5	1.2	3.7	1.2
Entomobrya corticalis (Nicolet,1842)	-	-	-	1.2	-	2.5
Sminthurinus sp.juv.	-	1.2	-	1.2	-	-
Isotoma anglicana Lubbock,1862	17.5	-	-	-	-	-
Isotoma violacea Tullberg,1876	2.5	-	-	-	-	-
Isotoma notabilis Schäffer,1896	6.2	-	1.2	-	3.7	6.2
Isotomurus palustris (Müller,1776)	2.5	-	-	-	-	-
Folsomia manolachei Bagnall,1939	7.5	15	5	6.2	37.5	17.5
Folsomia penicula Bagnall,1939	-	-	-	-	-	1.2
Isotomiella minor (Schäffer,1896)	-	5	1.2	2.5	2.5	31.2
Tetracanthella fjellbergi Deharv.,1987	-	92.5	41.2	23.5	53.7	41.2
Hypogastrura crassaegran. (Stach,1949)	1.2	-	-	-	-	-
Ceratophysella bengtssoni (Agren,1904)	-	-	6.2	1.2	35	5
Xenylla tullbergi Börner,1903	-	-	5	-	-	-
Friesea truncata Cassagnau,1958	3.7	2.5	-	-	-	-
Pseudachorutes parvulus Börner,1901	1.2	-	-	-	2.5	-
Micranurida sp.	-	-	-	8.7	1.2	1.2
Onychiurus subuliginatus Gisin,1956	-	21.2	26.2	2.5	1.2	1.2
Onychiurus franconianus Gisin,1961	-	1.2	1.2	11.2	3.7	-
Onychiurus vanderdrifti Gisin,1952	-	3.7	8.7	7.5	25	47.5
Onychiurus armatus (Tullberg,1869)	-	8.7	13.7	63.7	42.5	36.2
Onychiurus vontoernei Gisin,1957	-	-	-	1.2	-	-
Paratullbergia callipygos (Börner,1903)	-	1.2	2.5	-	3.7	2.5
Stenaphorura quadrispina Börner,1901	1.2	-	-	-	1.2	-
Mesaphorura krausbaueri Börner,1901	8.7	10	-	-	-	-
Mesaphorura hylophila Rusek,1982	33.7	21.2	3.7	5	1.2	1.2
Mesaphorura critica Ellis,1976	7.5	3.7	-	1.2	-	-
Mesaphorura macrochaeta Rusek,1976	2.5	12.5	2.5	-	-	1.2
Mesaphorura jarmilae Rusek,1982	-	-	2.5	1.2	-	-
Protura:						
Eosentomon vulgare Szeptycki,1984	1.2	75	6.2	3.7	43.7	10
Eosentomon transitorium Berlese,1908	-	5	1.2	6.2	-	-
Eosentomon sudeticum Szeptycki,1985	-	2.5	-	-	6.2	7.5
Eosentomon bloszyki Szeptycki,1985	-	2.5	-	-	-	-
Eosentomon silesiacum Szeptycki,1985	-	1.2	-	-	11.2	-
Eosentomon sp.n.	-	1.2	-	-	-	-
Eosentomon pinetorum Szeptycki,1984	-	-	33.7	20	13.7	-
Eosentomon germanicum Prell,1912	-	-	-	1.2	-	-
Eosentomon rafalskii Szeptycki,1985	-	-	-	-	-	1.2
Ex.100 cm^{-2}	127.5	313.7	186.2	392.5	303.7	222.5
H'	2.15	3.39	2.19	2.26		2.23
No of spp.	19	23	20	23	22	19

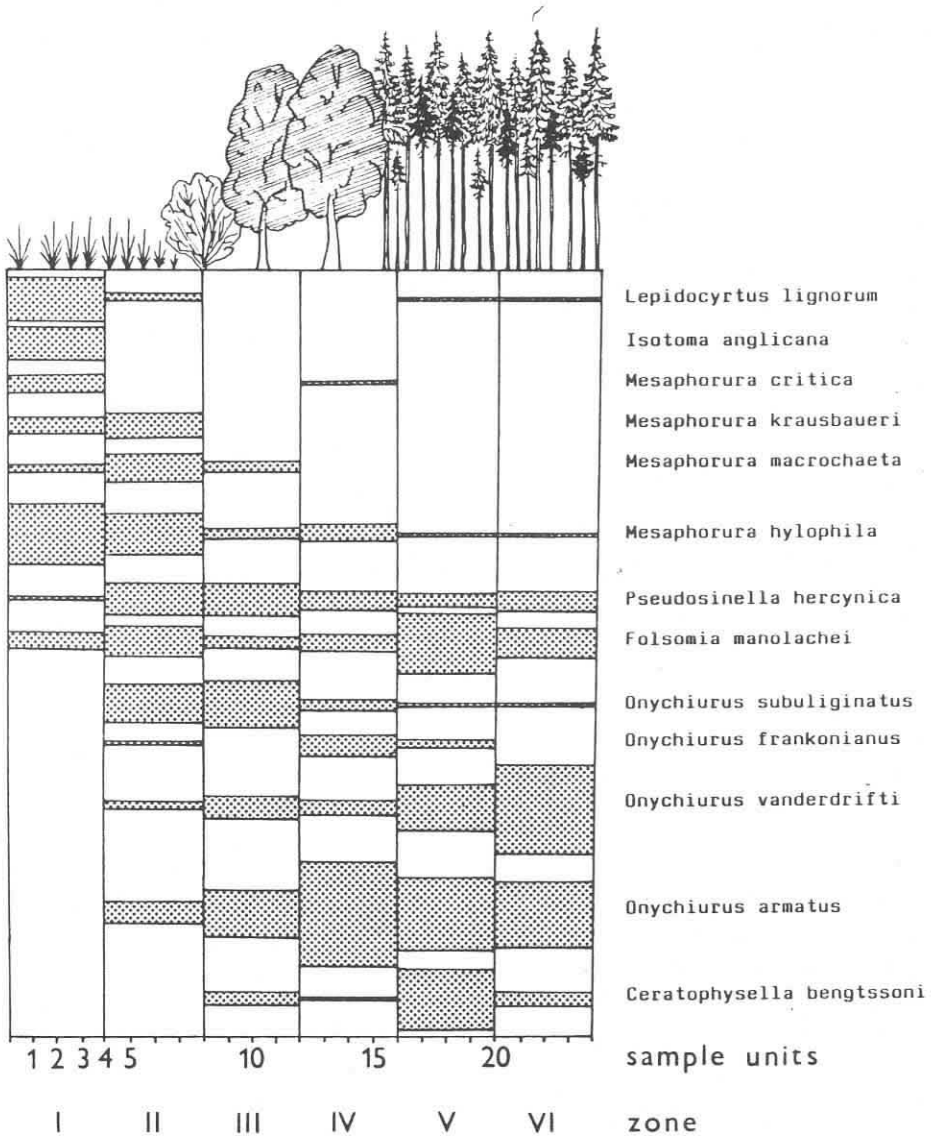

Fig.1: Distribution and density of some species of Collembola across the ecotonal zones I - VI.

ses. The plantcover is composed of Festuca rubra L., Deschampsia cespitosa, Agrostis tenuis Sbth., Melampyrum pratense L., Chrysanthemum leucanthemum, Selinum carvifolia L., Galium pumillum Murr., Ajuga reptans L., Lysimachia nummularia L., Hypericum maculatum Cr. and others. Humus form is mull.

Zone III (outer forest edge) was below the tree tops, sample sets 9 - 12. It is composed of trees and shrubs of Quercus robur L., Pinus silvestris L. and Betula verrucosa Ehrh., and Festuca ovina L., Luzula albida (Hoffm.), Hieracium sabaudum L., H. murorum L., Melampyrum pratense, mosses and lichens (Cladonia spp.) in understory. This zone is strongly exposed to sunshine the whole year long. The soil is covered with a 2 - 3 cm deep layer of microarthropod moder.

Zone IV (inner forest edge), sample sets 13 - 16 was on the inner forest edge. The shrubs and herbs are almost missing in the understory, only some tufts of Luzula albida are present here. Soil surface is covered with 1 - 2 cm layer of oak and pine litter. Humus form is moder, forming a 3 - 5 cm layer.

Zone V (forest), sample sets 17 - 20 was inside spruce stand (Picea abies L.) with sporadic fir trees (Abies alba L.). In the understory are present only sparse tufts of Luzula albida and cushions of moss (Polytrichum sp.). Humus form is moder, forming 2 - 3 cm horizon covered with 1 cm layer of spruce litter.

Zone VI (forest), sample sets 21 - 24: the stand characteristics as for zone V.

3. Methods

A 23 m long transect was marked out from the meadow to the forest to establish the typical ecotonal zones (Fig. 1). The samples were taken in two parallel rows 1 m from each other along the transect. 24 sample units of 2 cores 10 cm^2 and 10 cm deep were collected on 15.10. 1985 and processed in a high gradient Tullgren-apparatus.

4. Results

34 species of Collembola and 9 of Protura were found in the samples from all ecotone zones (Tab. 1). Their highest density was reached in zones IV and II, the lowest one in the meadow soil (Tab. 1). The highest species number (23 spp.) was in the zones with the highest density; the lowest (19 spp.) was in the meadow and spruce forest (Tab. 1). The highest Shannon-Weaver index of diversity was calculated for the meadow edge ($H' = 3.39$), the lowest for the meadow ($H' = 2.15$) (Tab. 1). Five species lived exclusively in the meadow zone I; the number of such species for the zones II, III, IV, V and VI was 2, 1, 2, 0 and 1 respectively (Tab. 1). The edge phenomenon had a positive effect on collembolan and proturan communities in the zones II and IV. For Protura alone the zone II was the most favorable (6 spp., 87 ex. 100 cm^{-2}).

The species distribution across the ecotone show differences in their density or presence in the particular zones (Fig. 1, Tab. 1). We may distinguish four ecological types of species: grassland, forest or edge inhabitants, and species with wider ecological plasticity. To the grassland species belong Isotoma anglicana, Mesaphorura krausbaueri, M. hylophila, M. critica and Lepidocyrtus lignorum. They live exclusively in the meadow soil (including its edge) or reach here high density, and they are missing or occur in very low densities in other zones. Typical forest species are Tetracanthella fjellbergi, Isotomiella minor, Ceratophysella bengtssoni, Onychiurus vanderdrifti, Onychiurus armatus and Eosentomon vulgare. They occur in all forest zones, in some of them in high densities, and do not penetrate behind zone II into the meadow. Typical for the edge zones II, III and (or) IV are Onychiurus subuliginatus, O. franconianus, Mesaphorura macrochaeta and

Eosentomon pinetorum. Pseudosinella hercynica and Folsomia manolachei belong to the species with wider ecological plasticity, but those species, too, find in some zones better conditions, reflected through a higher density (Fig. 1).

The ecological requirements of Protura are less clear due to their lower density and species number. But also in them the occurence and density of some species show a preference for a particular zone (Tab. 1).

4. Discussion

The Collembola and Protura are distinctly influenced by the ecotonal effect. They show different density patterns and community parameters across the ecotone. The abiotic and biotic factors change substantially in the transitional zone between the adjacent ecosystems - the meadow and the spruce forest (Rusek, in press). There are differences not only in such fundamental factors for soil biota as soil moisture and temperature across the ecotone, but also in the humus form, soil microstructure, soil microfauna and microflora. Therefore our species classification in meadow and forest forms concerns the described ecotone only. For example Onychiurus armatus and Isotomiella minor live in other cases in grasslands, too (cf Rusek, 1984), but the infavourable soil microstructure in the meadow of the ecotone studied does not allow immigration of the larger euedaphic species from the forest and transitional zones. On the other hand, Friesea truncata is also a ubiquistic species, but it does not penetrate from the grassland into the ecotone or even into the forest in our case. It is a predaceous species feeding on free-living soil nematodes. Its prey reached the highest density in the grassland. It was established that the distribution of some groups of soil algae is highly dependent on light conditions on the forest edge and in the forest. The occurrence of algivorous Collembola in the meadow, e.g. Isotomurus palustris, Isotoma anglicana, can coincide with their main food resource, too (Rusek, in press). Our findings are restricted to one sampling date only and do not reflect the dynamic processes in the ecotone. The transect studies enabled us to distinguish five ecologically distinct zones (meadow, meadow edge, outer and inner forest edge and forest) in which the dynamic processes were studied during one year, but the result will be published in a separate contribution.

6. Conclusion

The distribution of Collembola and Protura in a transect through a grassland - spruce forest ecotone was studied. The ecotone influenced positively the density and diversity index of collembolan and proturan communities and the species distribution across the ecotone. Four ecological types of species were distinguished: grassland, forest and edge inhabitants, and species with wider ecological plasticity. The studies of Collembola a Protura enabled to deliminate five di-

stinct ecological zones in the ecotone for further studies of dynamic processes.

7. References

Castri F di, Hansen HJ and Holland MM, èdtrs (1988) A new look at ecotones: emerging international projects on landscape boundaries. Biol International, Special Issue 17: 1-163.

Rusek J (1984) Zur Bodenfauna in drei Typen von Überschwemmungswiesen in Süd-Mähren. Rozpravy Českosl Akad Věd, Řada Mat Přír Věd, Academia Praha 94(3): 1-126 + 8 Tab.

Rusek J (in press) Distribution and dynamics of soil organisms across ecotones. SCOPE.